

Objectives:

- Learn MIPS assembly language format
- Learn how numbers are represented and stored
- Learn about math operations

## MIPS ADDRESSING MODE

displacement (base register)

ex.  $4(\$t0)$  CAN ALSO HAVE  $-24(\$t0)$   
W-BITS

NUMBERS

$$X = \{x_{w-1} x_{w-2} \dots x_0\}$$

WEIGHTS  $2^{w-1} \quad 2^0$

UNSIGNED Value =  $\sum_{i=0}^{w-1} x_i 2^i$

$$\begin{matrix} 2^2 & 2^1 & 2^0 \\ 2 & 2 & 2 \\ 4 & 2 & 1 \end{matrix}$$

MAX Value = ALL BITS ARE 1 =  $2^w - 1$   
MIN Value = " " " 0 = 0

SIGNED Value =  $\underbrace{-2^{w-1} x_{w-1}}_{\text{NEG}} + \underbrace{\sum_{i=0}^{w-2} x_i 2^i}_{\text{POSITIVE}}$

$$\begin{matrix} -2^2 & 2^1 & 2^0 \\ 1 & 0 & 0 & = -4 \\ 1 & 0 & 1 & = -3 \\ 1 & 1 & 0 & = -2 \\ 1 & 1 & 1 & = -1 \end{matrix}$$

SIGNED - 1 111 111 = -1

SIGNED MAX 0111 1111 ... =  $2^{w-1} - 1$   
MIN 1000 0000 ... =  $-2^{w-1}$

## MULTIPLY USING SHIFTS

$$00101 = 5$$

MULT BY 2

$$\begin{matrix} 0 & 1 & 0 & 1 & 0 & \leftarrow \text{INSERT } 0 \\ 16 & 8 & 4 & 2 & 1 \end{matrix} = 10$$

MULT BY 2 AGAIN

$$\begin{matrix} 0 & 0 & 1 & 0 & 1 & 0 & 0 & \leftarrow \text{INSERT } 0 \\ 16 & 8 & 4 & 2 & 1 \end{matrix} = 20$$

INSERT  
0's  
→

DIVIDE BY 2

0 0 0 0 0 0 1 0

LOGICAL RT SHIFT

ALWAYS SHIFT IN

ZEROS

UNSIGNED

DIVIDE BY 4

SIGNED

W=4 →

1 0 1 0

= -6

ARITHMETIC RT SHIFT

REPLICATE MSB

1 1 1 0

-8 + 6 = -2

+1

- ROUND TO ZERO

-1